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Computational Cognitive Neuroscience Modeling of Sequential Skill Learning

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14. ABSTRACT
The overall aim of this grant proposal was to build a computational cognitive neuroscience model of how the feedback can be optimized in order to influence learning of complex sequential skills. The model was then tested with a rich set of empirical data from aggregate feedback settings that was used to test the model and to facilitate further model development. The impact of the work is broad as it has the potential to change the way that we think about the learning of complex sequential skills that are ubiquitous in the day-to-day lives of military personnel, and it has the potential to lead to the development of training protocols that optimize the learning of sequential skills.

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Grant Title: **Computational Cognitive Neuroscience Modeling of Sequential Skill Learning**
Grant #: FA9550-12-1-0355
Reporting Period: July 1, 2014 to June 30, 2016 - Final

Accomplishments:

In this project we proposed a mix of theoretical and empirical studies that focus on how the feedback signal propagates backwards during the learning of complex sequential skills. Unlike most sequence-learning studies, our goal is not to understand how response-response associations develop, but rather to understand how each component of a complex sequential skill responds to feedback provided after the last component is executed. Only through such understanding will it be possible to develop training methods that optimize complex sequential skill learning.

To achieve these goals we developed and formalized a new paradigm call the aggregate-feedback category learning task. We have completed a number of studies using the aggregate-feedback task as well as other relevant tasks. We developed a computational cognitive neuroscience model of performance in this task and used these data for testing and modifying the model. We continue to collect new data and continue to fine tune the model.

The research addressed five specific goals, listed below with their final status:

- Build an initial computational cognitive neuroscience (CCN) model of feedback back-propagation during sequential skill learning.
    - Status: Complete.
- Collect a rich test-bed of empirical data from aggregate feedback settings.
    - Status: Complete, but with several studies follow-up studies ongoing.
- Test and modify the model using these data.
    - Status: Complete, with weveral improvements to the model that were obtained using the behavioral data. Continued improvements could be future work.
- Identify environmentally optimized and challenged (e.g., pressure, load) conditions.
    - Status: Initial load and pressure studies completed.
- Test and modify the model using these data
    - Status: Initiated; considered for future work.

Archival publications (published) during reporting period:

1. Ashby, F. G. (2015). An introduction to fMRI. In B. U. Forstmann & E.-J. Wagenmakers (Eds.), *An introduction to model-based cognitive neuroscience* (pp. 91-112). New York: Springer.
2. Ashby, F. G., (2014). Is state-trace analysis an appropriate tool for assessing the number of cognitive systems? *Psychonomic Bulletin & Review*, 21, 935-942.
3. Ashby, F. G., & Soto, F. A. (2015). Multidimensional signal detection theory. In: J. R. Busemeyer, Z. Wang, J. T. Townsend, & A. Eidels (Eds.), *Oxford handbook of computational and mathematical psychology* (pp. 13-34). New York: Oxford University Press.
4. Blanco, N.J., Love, B.C., Cooper, J.A., McGeary, J.E., Knopik, V., & Maddox, W.T. (in press). A frontal dopamine system for reflective exploratory behavior. *Neurobiology of Learning and Memory*.

5. Cantwell, G., Crossley, M. J., & Ashby, F. G. (2015). Multiple stages of learning in

perceptual categorization: Evidence and neurocomputational theory. *Psychonomic Bulletin & Review*, in press.

6. Chen, M-Y., Jimura, K., White, C.N., Maddox, W.T., & Poldrack, R.A. (2015) Multiple brain networks contribute to the acquisition of bias in perceptual decision making. *Frontiers in Neuroscience*.
7. Crossley, M. J., & Ashby, F. G. (in press). Procedural learning during declarative control.
8. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.
9. Crossley, M. J., Ashby, F. G., & Maddox, W. T. (2014). Context-dependent savings in procedural category learning. *Brain & Cognition*, *92*, 1-10.
10. Crossley, M. J., Paul, E. J., Roeder, J., & Ashby, F. G. (in press). Declarative strategies persist under increased cognitive load. *Psychonomic Bulletin & Review*, in press.
11. Helie, S., Ell, S. W., Ashby, F. G. (2015). Learning robust cortico-cortical associations with the basal ganglia: An integrative review. *Cortex, 64*, 123-135.
12. Helie, S., Ell, S.W., Filoteo, J.F., & Maddox, W.T. (2015). Criterion learning in rule based categorization: Simulation of neural mechanism and new data. *Brain & Cognition*, *95*, 19-34.
13. Soto, F. A., Vucovich, L., Musgrave, R., & Ashby, F. G., (2015). General recognition theory with individual differences: A new method for examining perceptual and decisional interactions with an application to face perception. *Psychonomic Bulletin & Review*, *22*, 88-
14. Valentin, V. V., Maddox, W. T., & Ashby, F. G. (2014). A computational model of the temporal dynamics of plasticity in procedural learning: Sensitivity to feedback timing. *Frontiers in Psychology – Cognitive Science*, *5*, article 643, 1-9.
15. Worthy, D.A. & Maddox, W.T. (2014). A comparison model of reinforcement-learning and win-stay-lose-shift decision-making processes: A tribute to W.K. Estes. *Journal of Mathematical Psychology*, 59, 41-49.

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FA9550-12-1-0355

Principal Investigator Name
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David M Schnyer

Program Officer
The AFOSR Program Officer currently assigned to the award

Dr. Jay Myung

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Reporting Period End Date

06/30/2016

Abstract

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Archival Publications (published) during reporting period:

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Ashby, F. G. (2015). An introduction to fMRI. In B. U. Forstmann & E.-J. Wagenmakers (Eds.), An introduction to model-based cognitive neuroscience (pp. 91-112). New York: Springer.

Ashby, F. G., (2014). Is state-trace analysis an appropriate tool for assessing the number of cognitive systems? Psychonomic Bulletin & Review, 21, 935-942.

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in procedural learning: Sensitivity to feedback timing. Frontiers in Psychology – Cognitive Science, 5, article
643, 1-9.

New discoveries, inventions, or patent disclosures:

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No

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Do you plan to pursue a claim for personal or organizational intellectual property?

Changes in research objectives (if any):

NONE

Change in AFOSR Program Officer, if any:

NA

Extensions granted or milestones slipped, if any:

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AFOSR LRIR Number

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Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, $K)

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Salary			
Equipment/Facilities			
Supplies			
Total			

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Appendix Documents

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